European Journal of Operational Research 000 (2018) 1–13

Contents lists available at ScienceDirect

European Journal of Operational Research

journal homepage: www.elsevier.com/locate/ejor

Emerging trends and new frontiers in community operational research

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ARTICLE INFO

Article history:
Received 4 January 2017
Accepted 15 November 2017
Available online xxx

Keywords:
Community operational research
Community-based operations research
Analytics
Developing countries
Systems thinking

ABSTRACT

Community Operational Research (Community OR), and its disciplinary relation, Community-Based Operations Research, has an increasingly high profile within multiple domains that benefit from empirical and analytical approaches to problem solving. These domains are primarily concentrated within non-profit services and local development. However, there are many other disciplines and application areas for which novel applications and extensions of Community OR could generate valuable insights. This paper identifies a number of these, distinguishing between 'emerging trends' (mostly in well-studied areas of operational research, management science and analytics) and 'new frontiers', which can be found in traditions not commonly oriented towards empirical and analytical methods for problem solving, where community-engaged decision modeling represents new ways of generating knowledge, policies and prescriptions. This paper will show how the exploration of emerging trends and new frontiers in Community OR can provide a basis for the development of innovative research agendas that can broaden the scope and impact of the decision sciences.

1. Introduction

Community Operational Research (Community OR), and its disciplinary relation, Community-Based Operations Research (CBOR), has an increasingly high profile within multiple domains that benefit from empirical and analytical approaches to problem solving. Many of these areas are concentrated in human services, community and economic development, education and other non-profit services, and the nature of inquiry tends to be influenced by action research and systems thinking as much as traditional decision modeling. However, there are many other areas of inquiry in which Community OR has had only a modest presence to date.

The goal of this paper is to explain how Community OR can help identify problem opportunities, novel analytical methods, theory-building and contributions to practice in a variety of domains, some closely identified with operational research, management science and analytics (henceforth referred to generally as the 'decision sciences'), and others more firmly rooted in disciplinary traditions not conventionally associated with decision science. By doing so, we hope to provide encouragement and resources for researchers and practitioners who seek new applications for Community OR that support frequently-pursued Community OR values, such as community engagement, equity and social justice.

We start by providing a short introduction to Community OR, and in so doing we clarify distinctions between this and other areas of decision science. Elsewhere (Midgley, Johnson, & Chichirau, 2018), we argue that the definitive feature of Community OR is "the meaningful engagement of communities", which leaves open questions about what counts as 'meaningful' (see Ufua, Papadopoulos, & Midgley, 2018, for a discussion of this) and what constitutes a 'community' (e.g. Midgley & Ochoa-Arias, 1999). Importantly, defining Community OR in this way draws out a principle of practice (meaningful community engagement) that is present in all previously published examples of Community OR, so this is not an imposition on our discipline. However, it also proposes a normative standard for future practice and publications, to limit the possibility of 'drift' into less community-engaged forms of OR.

Note that a consequence of this definition is that there are overlaps between Community OR and other well established traditions, such as public sector OR and even OR in the private sector (see Midgley et al., 2018, for examples). For instance, perfectly good public sector OR can be client-engaged, but not community-

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https://doi.org/10.1016/j.ejor.2017.11.032
0377-2217/

engaged. However, when the community actually has meaningful input, the project may be both public sector *and* Community OR. Below, we use public sector OR as an example to compare Community OR with, although we should provide a caveat here: many of the things we discuss below are *general characteristics* of Community OR compared with public sector OR, and the term 'general characteristics' refers to things that are commonly found in applications. This is different from saying they are *defining features* of Community OR. In our view, only the 'meaningful engagement of communities' can be considered definitional (in addition, of course, to things that are definitional of all forms of OR, like modeling).

Public sector OR has traditionally addressed three areas of decision modeling impacts: efficiency, effectiveness and equity (Savas, 1969, 1978). Bardach and Patashnik (2016) express efficiency as maximizing the sum of individual utilities, and Stokey and Zeckhauser (1978) characterize efficient solutions as lying on a Pareto frontier of possible allocations of goods and services among members of a population. Effectiveness, in contrast to efficiency, seeks to identify policies or interventions that best achieve socially desirable outcomes, especially when markets diverge greatly from the common neoclassical assumption of perfect competition, or when there are no easily identifiable markets for the goods or services of interest (LeClerc, McLay, & Mayorga, 2012). Finally, notions of equity, fairness or justice address concerns that a just society may take steps to ensure that certain groups receive benefits from policies or interventions roughly commensurate to their needs (LeClerc et al., 2012). Commonly used introductions to management science, such as Winston and Albright (2016), tend not to address efficiency directly, rather concentrating on objectives most salient to private sector operations, such as minimizing cost or maximizing yield or profit. Mainstream introductions to management science are equally silent on issues related to effectiveness and equity. Even standard reviews of public sector OR (see e.g. Pollock et al., 1994) have relatively little to say about issues of equity and social justice as compared with more traditional emphases on technical modeling.

Community OR is distinguished from client-but-not-community-engaged public sector operational research in a number of ways. First, Community OR places great emphasis on *intervention*, or "purposeful action by an agent to create change" (Midgley, 2000, p.9), as opposed to observational science alone or methodological innovations outside the context of interventions. Effective Community OR interventions require a deep understanding of the problem context, a commitment to empiricism, engagements with stakeholders, and primary data collection to reflect the lived experiences of those who are engaged with the problem to be solved (e.g. Friend, 2004). Many public sector projects also involve interventions, but the majority of the publications discussing them are framed in terms of novel modeling techniques and the findings from data analyses, with the engagement of clients and stakeholders that is required for effective intervention taking a back seat. Publications about Community OR projects, in contrast, tend to emphasize the latter alongside the reporting of methodological innovations (e.g. Johnson 2012a; Midgley & Ochoa-Arias, 2004a; Ritchie et al., 1994).

Next, in line with the focus on intervention, Community OR generally has a central concern for *local engagement and impact*. This arises from a belief that many problems of greatest immediate concern to citizens (such as education, crime, housing and economic development) have a local character, and that giving local residents a say in problem identification, formulation, solution and the implementation of new prescriptions or guidelines may result in significant and/or rapid improvements in (perceived) quality of life.

Community OR also usually has a concern for *disadvantaged, underrepresented and underserved populations*. This is about social justice, which involves efforts to promote "….a just society by challenging injustice and valuing diversity" (National Federation for Catholic Youth Ministry 2008) or ensuring "equal access to liberties, rights, and opportunities, as well as taking care of the least advantaged members of society" (Robinson, 2016). Social justice was a concern of those who first founded Community OR (e.g. Jackson, 1987; Rosenhead, 1986).

Community OR focuses on *problem solving processes as well as outcomes* (Midgley and Ochoa-Arias 2004b); in particular, designing interventions that are intended to improve the understanding of decision opportunities, data and solutions as much as to produce specific prescriptions or strategies (e.g. Ritchie, 2004). Johnson (2012b) argues that Community-Based Operations Research (CBOR), a domain closely aligned with Community OR, derives a great deal of value from

- Identifying problems which may not, at first glance, appear amenable to conventional OR methods;
- Formulating those problems in such a way as to prioritize diverse conceptions of values, evidence of beneficial social impacts and equity;
- Solving them (or addressing/managing them when no immediate resolution is possible) through multiple research frameworks and analytical methods that yield understanding as much as prescriptions; and
- Implementing solutions to enable capacity building and social change, with theory development being a possible outcome too.

Community OR embodies a *critical approach* and a *concern for ethics*. By 'critical approach', we mean a desire to

- Interrogate assumptions about whose conceptions of a problem count (e.g. Foote et al., 2007; Midgley & Pinzón, 2011; Ulrich, 1987, 1994, 1996);
- Explore the implications of power relationships between 'experts' who address problems, 'clients' who present problems to be solved, and communities who are the potential beneficiaries or victims of new policies or prescriptions (e.g. Córdoba & Midgley, 2006; Midgley & Milne, 1995);
- Understand the inevitably non-neutral role of the practitioner, and perceptions among stakeholders of his/her identity, which bring the need to link self-reflection with stakeholder dialogue, empirical-analytic inquiry and ideology critique (Gregory, 1992, 2000; Midgley, 1995); and
- Take seriously alternative research philosophies and methodologies, such as post-positivism, constructivism, transformative research, emancipatory inquiry and pragmatism (e.g. Creswell, 2014; Jackson, 1985; Metcalfe, 2008; Midgley, 2004; Ormerod, 2006; Taket & White, 1993).

'Ethics' refers to

- Concerns about the probity of engagements by researchers (e.g. issues of independence and honesty when there is a fee paying client and other stakeholders may suffer);
- The integrity of relationships between researchers, clients and participants, so exploitation of various kinds is avoided; and
- The consequences of decisions on those affected but not involved (Córdoba, 2009; Ormerod & Ulrich, 2013; Taket, 1994; Ulrich, 1994; Wenstop & Koppang, 2009).

Moral inquiry can shed light on the possible rights and responsibilities of stakeholders, especially in problematic situations (Mingers, 2011a). Likewise, Midgley, Munlo, and Brown (1998) follow Ulrich (1987, 1994, 1996) in arguing that every boundary judgment made in a Community OR project (about whose views and what issues to include, exclude or marginalize) is also an ethical judgment, so ethics has to be a central concern for practice.

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In contrast with many others working in operational research, management science and analytics, Community OR practitioners tend to exhibit a methodological preference for *qualitative* (e.g. Mingers & Rosenhead, 2004; Rosenhead & Mingers, 2001) and *mixed method* (e.g. Mingers and Gill, 1997) approaches to problem solving, as opposed to the traditional foci on quantitative data, mathematical modeling and the manipulation of quantitative data via algorithms. The tension between those advocating for qualitative versus quantitative methods is long-standing within OR/MS (Kirby, 2007; Mingers, 2011b, 2011c) and, to some extent at least, mixed method approaches are able to transcend this by accepting the validity and utility of both (e.g. Flood and Jackson 1991; Flood and Romm 1996; Midgley, 1992, 1996, 2000; Midgley, Nicholson, & Brennan, 2017; Mingers and Gill 1997).

Finally, Community OR practitioners generally seek to design interventions that result in *community empowerment and social change*. They mostly eschew the idea that problem-orientated inquiry can be 'neutral' or 'value-free' (e.g. Alrøe, 2000; Midgley, 2000; Ulrich, 1994). This empowerment and social change orientation was partly introduced as a reaction to the right wing politics of the Thatcher era in the UK (e.g. Rosenhead, 1986), but has since expanded into a broader philosophy of 'engaged OR' (Midgley et al., 2018) that provides a counterweight to both unfettered capitalism and centralized bureaucratic planning (Jackson, 1987). As such, it represents a re-imagining of what operational research can do with and for communities in general, and disadvantaged and marginalized communities in particular, often using methods not considered within the mainstream of OR in the USA (Jackson, 1988; Midgley et al., 2018). Compare Simchi-Levi's (2006, 2009) defense of narrow boundaries for OR with Ackermann et al's (2009) appeal to take Soft OR, and by extension Community OR, seriously within the discipline.

Community operational research thus has many features that enable it to productively address a wide range of problems of social concern, including those traditionally considered to be the province of the social sciences, human services and information technology, as distinct from the decision sciences. We explore the relationship between Community OR and these domains in the remainder of this paper, which is organized as follows. Section 2 discusses challenges and opportunities for Community OR in research and practice. Section 3 presents emerging trends, primarily in the decision sciences and related fields, where OR is well positioned to have a substantial impact in the shorter term, and where Community OR might make a useful contribution. Section 4 discusses new frontiers: primarily areas distinct from the decision sciences, where there are longer-term prospects for Community OR's impact in practice and scholarship. Section 5 concludes with elements of a research agenda built upon the previous reflections.

2. Challenges and opportunities

Community operational research faces a number of barriers to widespread acceptance in teaching and research in decision science, and impact in practice commensurate with its social justice motivations. First, ordinary citizens may lack the expertise needed for data-driven problem solving, and therefore require considerable support (Gregory & Atkins, 2018; Ritchie, 2004). This is arguably one reason why there is more of an emphasis in Community OR on the participative use of qualitative methods. Also, Community OR often requires organized and sustained participation among multiple stakeholders for problem identification, formulation and solution (Gregory & Midgley, 2000; Taket & White, 2000), which may run counter to a tendency to rely on government and nonprofit organizations to take the lead. Updating and managing sociotechnical systems is difficult, and is more commonly performed by trained practitioners working in established organizations. Knowledge generated by Community OR studies does not necessarily lead to the production of expert prescriptions in the sense traditionally understood within operational research, industrial engineering and related fields; rather, the practitioner may facilitate a process of learning that flows seamlessly into decision making without any need for expert recommendations (for examples, see many of the 26 case studies of practice in the book edited by Bryant, Ritchie, & Taket, 1994). Of course, most studies in the decision sciences with an application focus aspire to implementation as an end goal. However, special interests inside and outside the community may divert energy and enthusiasm towards aims not always shared by local actors. Stakeholder participation can be an antidote to this (Rosenhead & Mingers, 2001), but there also has to be a recognition that, in some contexts, there are stakeholders who try to get their way through manipulation or coercion rather than through engagement in free and fair dialogue (Jackson, 1991, 2006; Midgley, 1997), so this can make the design of Community OR projects and pathways to implementation quite complex. Online engagement is now relatively common in the current era of social media, especially with spatially dispersed communities, but there are barriers to the use of this in Community OR: it is not easy to translate the energy created online into in-person activism, especially if it requires sustained local action. Finally, there are few innovations within Community OR that have as high a profile within popular discourse as those associated with more traditional conceptions of OR, which reflect a traditional efficiency-enhancing approach and are rooted in the metaphors of logistics and business operations. Examples of these include manpower scheduling, revenue management, vehicle routing and production and operations management. Greater visibility is needed for our work.

However, despite the above challenges, Community OR and Community-Based Operations Research may also benefit from a number of opportunities to transform the decision sciences. Operational research for the public good, especially to benefit resource-constrained and mission-driven nonprofit organizations, has received substantial visibility through a student paper contest sponsored by the Institute for Operations Research and the Management Sciences called 'Doing Good with Good OR' (INFORMS 2016a) as well as an edited volume sponsored by this society that is dedicated to public applications of operations research (Kaplan, 2015). There are also volunteer-driven initiatives of professional societies in the US ('Pro Bono Analytics', INFORMS 2016b) and the UK ('Pro Bono OR', Operational Research Society 2016). Scholars such as Mettler (2011) have demonstrated the importance of the 'submerged State' in diverting public benefits to most-privileged populations, providing a basis for Community OR researchers and practitioners to design interventions to reconcile technocratic/managerial understanding with people's real-world concerns. Current research in e-government and e-governance (Manoharan, 2015; Chen and Ahn, 2017) demonstrates the potential for internet-enabled applications to provide high quality and rapid response services that can increase the level of trust between citizens, nonprofits and government. Initiatives and applications such as these may increase the likelihood that Community OR initiatives can be successful. These promising trends require an increased awareness by citizens of root causes of social concerns and the potential of localized direct action to address them, but the recent elections in the US and the EU ('Brexit') referendum in the UK may cast doubt on the willingness of many citizens to examine systemic barriers to an improved quality of life. In the face of this, we suggest that the primary opportunity for Community OR to increase its breadth and impact are specific application areas for which practitioners may provide novel and highly influential insights, strategies and operational recommendations. By doing so, we argue that Community OR, and indeed OR more generally, may increasingly be seen

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as an attractive and easily-understood means by which to improve the quality of life of individuals and communities in ways not limited to market transactions and the activities of large organizations. We describe these application areas in the two sections that follow.

3. Emerging trends

Over the past 15–20 years, new areas within operational research have emerged to respond to contemporary issues in the public and private sectors that go beyond the traditional core foci of OR. As these new domains have become more closely associated with the mainstream of OR, there are increasing opportunities for Community OR to address them by adapting models, analytical methods and methodologies to strengthen a focus on community engagement and social change. Community OR practitioners can therefore make worthwhile contributions in the new areas while simultaneously moving our specialism more into the mainstream of OR. To us, the three most interesting emerging trends where Community OR can contribute something new, or gain something, are disaster planning, analytics and Behavioral OR. These are discussed below.

3.1. Disaster planning

Recent work in disaster planning has critiqued common assumptions about expertise, and has focused on the role of communities in such planning. Auf der Heide (2006) reviews the literature and practice of medical planning for disasters. He shows that, while it is commonly assumed that trained emergency personnel carry out field operations, in most cases the initial rescues are done by survivors themselves (p. 36). Eisenman, Cordasco, Asch, Golden, and Glik (2007) attempt to understand the evacuation decisions of New Orleans residents in the context of Hurricane Katrina by looking at their interviewees' community ties. The researchers use a grounded theory approach to analyze responses from residents of Houston's major evacuation centers. In their discussion, they insist that evacuation must be studied much beyond the individual level, as "broad networks of families and friends create demands on participants" (Eisenman et al., 2007, p. 113).

Another promising avenue of research has been opened by Houston et al. (2015), who have developed a framework for using social media in disasters - with the main goal of implementing beneficial social media processes at all levels, including improving community resilience and reconnecting the community post-disaster. However, their section on how to heal fractured community links is rather short, especially in light of the recognized potential of social media uses (Houston et al., 2015, p. 15). There is room for much development here. In addition, Becker, Matson, Fischer, and Mastrandrea (2014) have examined stakeholder engagement and quantitative analysis for pre-disaster planning.

As a special case of disaster planning, humanitarian logistics applications tend to be conceived at the systems level and rely on mathematical modeling and solution algorithms associated with traditional OR (Duran, Ergun, Keskinocak, & Swann, 2012, Ekici, Keskinocak, & Swann, 2014; Liberatore, Ortuño, Tirado, Vitoriano, & Scaparra, 2014). One humanitarian logistics application, however, emphasizes appropriate information technology to support 'last mile' distribution of goods in communities with compromised infrastructures, developed in conjunction with local stakeholders (Ergun, Guyi, Heier-Stamm, Keskinocak, & Swann, 2014). While there has been a Community OR project on disaster planning (Gregory & Midgley, 2000), this predates the bulk of research in humanitarian logistics and does not speak to its focus on solving technical problems regarding the optimal positioning of goods and services pre- and post-disaster. Community OR can enable researchers and practitioners to integrate stakeholders' experiences and preferences directly into an enhanced model development process that highlights difficulties in on-the-ground, disaster-related logistics. These difficulties include fear, uncertainty, corruption, political oppression and so on (Munday, 2015).

3.2. Analytics

The discipline known as analytics comprises three distinct tasks: descriptive analytics, or the study of systems, organizations and phenomena according to historical data; predictive analytics, or the informed estimation of future values of variables or configurations of systems to aid in the anticipation of as yet unknown events; and prescriptive analytics, or the design of policies, guidelines or practices based on optimal or best possible values of decision variables assumed to be under the control of the modeler (Liberatore & Luo, 2010). Motivated by the explosion of data from processes and devices, the business process redesign movement and the widespread availability of sophisticated software, analytics has in many ways become the public face of the professions known heretofore as 'operational research' and 'management science'. Of course, the relabeling of disciplines and research communities is always contentious because professional identities are at stake, and there is clearly an ambiguous relationship between OR and analytics (Mortenson, Doherty, & Robinson, 2014). Popular treatments of analytics are numerous, including Nussbaumer Knaflic (2015) and Siegel (2016). The Institute for Operations Research and the Management Sciences, for example, has developed an analytics credentialing program for practitioners (INFORMS 2016c) and a new analytics maturity model to facilitate organizational redesign through analytics (INFORMS 2016d).

Though analytics is most often conceived as a quantitative domain, recent work has emphasized the role that problem structuring methods (PSMs) and other qualitative methods may play in it (Ranyard, Fildes, & Hu, 2015). Community OR, which makes frequent use of PSMs, may benefit from emphasizing its relationship with analytics, interpreted broadly as ways to solve practical problems using diverse methods, some of which involve quantitative data. Indeed, an association between the two areas has already been made by Hindle and Vidgen (2018). Community OR may make contributions to analytics by emphasizing questions of

- What data can and should do for individuals, communities and organizations;
- Whether concepts such as effectiveness, social impact, institutional challenges and the like are, or can be, taken seriously by decision makers seeking to quantify various aspects of an analysis; and
- Most importantly for Community OR, how community residents themselves (and their representatives) can work with organizations to define, collect and analyze data that are relevant to their own lives (see the subsection on 'big and difficult data' below).

Some of these questions have been addressed in the context of volunteer consulting engagements sponsored by Pro Bono Analytics (INFORMS 2016b) and Pro Bono OR (ORS 2016).

3.3. Behavioral OR

While humanitarian logistics and analytics are high profile new areas where Community OR might make substantial contributions, the third emerging trend to be discussed, Behavioral OR (e.g. Franco & Hämäläinen, 2016; Hämäläinen, Luoma, & Saarinen, 2013), is one where the benefit is most likely to be in the other direction: we argue that Community OR, along with OR more

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broadly, can learn something significant from Behavioral OR. Indeed, this learning has already started (Velez-Castiblanco, Brocklesby, & Midgley, 2016).

There are actually several different strands of Behavioral OR (Becker, 2016; Franco & Hämäläinen, 2016), but the one we are most concerned with here involves the close study of participant and practitioner interactions and communications to identify what, in the OR modeling process, makes a critical difference in terms of participant learning and decision making (e.g. Brocklesby, 2016; Luoma, 2016; Scott, Cavana, & Cameron, 2016; Tavella & Franco, 2015; Thompson et al., 2016; White, Burger, & Yearworth, 2016). By recording and viewing the micro-level interactions in OR workshops, behavioral researchers aim to discover critical factors for success and failure so that future OR practice can be designed to account for these.

As far as we are aware, there has been only one application of behavioral analysis to a project explicitly identified as Community OR: see Foote, Ahuriri-Driscoll, Hepi, Midgley, and Earl-Goulet (2016) for details of the project, and Velez-Castiblanco et al. (2016) for the analysis. Velez-Castiblanco et al. (2016) examined how the OR team collaborated on the design of a mixed-methods intervention, and were able to show that the design process was very different from the rather sanitized accounts of method selection usually presented in the OR literature (also see Keys & Midgley, 2002, Midgley, 2000, and Ormerod, 2014, for critiques of this sanitization). The design process involved the deployment of a great deal of tacit knowledge as well as various tactics of influence and persuasion. The authors' theory of 'boundary games' provides a way of thinking about communications that

> "…can support greater mindfulness, both when OR teams are designing an intervention and when the intervention is being undertaken. By 'mindfulness', we mean conscious reflection in the context of the flow of dialogue and action, which can augment the tacit knowledge that is inevitably a major feature of OR processes" (Velez-Castiblanco et al., 2016, p.979).

Future analyses of Community OR projects could feature examinations of the interactions of participants around models; these could be significant in the evaluation and accelerated improvement of practice.

4. New frontiers

In contrast with the three domains described above, there are a number of other research areas which have had identities substantially or largely distinct from OR, but which have characteristics that are supportive of innovations within Community OR (and CBOR). Community OR draws its power from the insights it may provide on contemporary policies, application contexts and technologies that have an impact on spatially distinct and constrained groups of people and infrastructures. Here we want to discuss how Community OR may be applied to a number of new frontiers, and what the discipline may learn from these new applications. Clearly, there are many more new frontiers than can be covered by a single paper, but we have selected nine that seem to us to be particularly promising, either because work is already going on to inform them with Community OR (e.g., community-based intervention in developing countries), or because people in those areas share common values with Community OR practitioners (e.g., working in the service of indigenous people on issues of concern in their communities).

We are not aware of any single theoretical framework that we could have used to select the frontiers for review, as there are diverse social forces shaping them and no one theory neatly covers them all. Some of these social forces include urbanization and the mitigation of slums, especially in developing countries (e.g. Davis, 2007); access to education and education reform (e.g. Adamson, Astrand, & Darling-Hammond, 2016); community health, including food security and access to health care (e.g. Galea and Vlahov, 2005); shrinking cities and municipal decline, especially in developed countries (e.g. Weaver, Bagchi-Sen, Knight, & Frazier, 2017); neighborhood resilience and disaster planning (e.g. Hicks Masterman et al., 2014); crime, disorder and community safety (e.g. Bowden, 2014); sustainable cities (McLaren & Agyeman, 2015); diversity, inclusion and multiculturalism (e.g. Vertovec and Wessendorf, 2010) and many others. Indeed, if we had artificially imposed a single framework on our analysis, it could have resulted in the omission of some important frontiers and an over-emphasis on others. We therefore rely primarily on our knowledge and experience for our selection.

4.1. Urban planning and community development

Urban planning, community development, urban affairs and related fields are focused on developing strategies to make homes, neighborhoods and cities better places to live for as many people as possible. This can be done by permitting, encouraging or forbidding certain types of physical infrastructure (urban planning); helping local residents advocate for their needs; developing local services and institutions (community development); and providing guidance and insight regarding all manner of products and services intended to meet the needs of urbanized communities (urban affairs) (see, e.g., Hall & Tewdwr-Jones, 2010; Levy, 2017). Since these fields have the improvement of life through peoples' daily activities as a core concern, there would seem to be a role for Community OR. Indeed, Johnson and colleagues have adapted principles of Community OR to address community responses to the housing foreclosure crisis, both at the higher level of project design (collaborating with community partners to identify and set research agendas; see Turcotte, Johnson, Chaves, Drew, & Sullivan, 2015) and at the lower level of executing particular research designs. In terms of the latter, examples are identifying local values associated with community revitalization and foreclosure response (Keisler, Turcotte, Drew, & Johnson, 2014) and developing a novel metric for community development that links strategy and impact (Johnson, Drew, Keisler, & Turcotte, 2012). Johnson, Hollander, and Davenport Whiteman (2015) have also employed some principles of Community OR to design and evaluate decision models for non-traditional local development to counter blight, vacancy and abandoned properties.

However, despite a wide range of potential application areas within the service sector (including transportation and warehousing, information and communication, human health and social assistance, financial and insurance services, and many more), documented applications of *non*-Community OR in the service sector appear to be overwhelmingly concentrated on traditional quantitative, mathematical model-driven approaches (Zhong, Karner, Kuby, & Golub, 2017; Xing, Li, Bi, Wilamowska-Korsak, & Zhang, 2013). Community OR principles are actually quite prominent in contemporary treatments of community development (see e.g. Defilippis & Saegert, 2012) and new initiatives to build collaborations between researchers and practitioners for community development and social change exist (URBAN 2016), although they are not usually named as 'Community OR' in teaching and research contexts. Community OR may benefit greatly by emphasizing connections with urban/city planning and community development, and connecting well-understood methods for community engagement and design with decision science principles of problem identification, formulation and solution that have an emphasis on process learning and stakeholder impact rather than mostly on technical issues of mathematical modeling and algorithm design.

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4.2. Information systems and information technologies (IS/IT)

IS/IT is a well-studied domain, both in stand-alone academic disciplines and university departments and colleges, and is an active area of inquiry within the decision sciences (see e.g. *Information Systems Research*, http://pubsonline.informs.org/journal/isre). However, there has been relatively little attention paid by these disciplines to the design of community-engaged methods for problem solving in the OR tradition, and conversely relatively little attention has been paid within Community OR to IS/IT as either vehicles for solution implementation or domains within which intensive community engagement might be performed (Yearworth and White, 2018). There are, of course, exceptions: for instance, Córdoba and Midgley (2003, 2006, 2008) show how IS planning can put stakeholders (including those in the community) front and center through an approach based on critical systems thinking; and Barros-Castro, Midgley, and Pinzón (2015) apply a similar approach to the engagement of school children and teachers in the design of computer-supported collaborative learning programs. With this in mind, perhaps one of the most fruitful areas of potential interchange between Community OR and IS/IT researchers is that of citizen engagement. For both fields, acquiring knowledge on the ultimate 'end users' and ensuring their empowerment are central concerns (e.g. Córdoba-Pachón, 2010).

Another illustrative example comes from Barrett, Oborn, and Orlikowski (2016), who examine how value is created in online communities over time. They argue that researchers need to move away from considering online participants as largely homogenous, and towards identifying stakeholder groups and key participants. They do precisely that in a case study of an online healthcare community group, and such work showcases the potential of IS research for community engagement. Lopez (2015) does something related but different, while looking at the online behaviors of urban communities targeted by participatory information systems programs. She finds that the geographic targeting scope matters a great deal (local versus hyper-local), but also that off-site communication is essential to IS development, and the greatest challenge to online community sustainability is residential instability. To avoid marginalization, designers of participatory information systems must engage transient populations as well as those remaining for longer periods of time. In any case, research indicates that information systems seeking to engage small, urban communities need to be designed differently from sites with a global reach. Raymaker (2016) is an example of a practitioner who explores the latest IS research on direct engagement using critical systems thinking and community-based participatory research. Her study is an exploration of the development process of a healthcare-focused web site for autistic end users, but the implications for further research are immediately obvious: what would be different if the engagement was directed at other populations or organizational contexts?

Thus, Community OR could transform IS/IT by emphasizing community-engaged methods for systems design and implementation, drawing connections between technical innovations and conventional notions of usability, and the expressed needs of especially disadvantaged end-users whose low income, lack of social status and influence may make them more often seen as consumers of IS/IT innovations rather than sources of such.

4.3. Big and difficult data

The past decade or so has seen an explosion of research in the area of 'big data', commonly understood to be the collection of very large datasets routinely generated through information systems such as point-of-sale systems, social media, public surveillance and the 'internet of things' (Bollier, 2010). Big data can be seen as an aspect of analytics, but the focus here is more on the sources of the data, and the special problems associated with handling huge repositories of data, constantly refreshed from diverse sources in real time. While datasets and analyses of big data are usually dominated by experts working at a distance from local communities, there is growing evidence of community participation in large scale data analysis, through crowd-sourcing and community activism (Calvard, 2016). Moreover, researchers are increasingly exploring issues related to the curation of large datasets of public and local interest (Bertot, Butler, & Travis, 2014) and community collaborations to extract alternative meanings from large datasets (Couldry & Powell, 2014).

Another approach to data analytics and community engagement arises from the notion that, in many cases, the data that are most relevant to community needs, especially disadvantaged and lower-income communities, are not 'big' at all, but challenging because of a lack of consensus on what data elements should be collected, from what sources and put towards what ends (which explains why this section has a title distinct from simply 'big data'). Also, even modestly-sized datasets can tax the capacity of mission-driven nonprofit organizations (Boland, 2012; Johnson, 2015; Johnson et al., 2015). The research on this conveys in aggregate a substantial opportunity for Community OR to fully engage in research on data science and analytics, using our discipline's unique perspective on local agency and a critical approach to identify novel applications for data collection, analysis and use for local development. One contemporary application of community data analytics, for example, is the issue of defining specific metrics for measuring the impacts of local economic development, with data collected by grass-roots organizations that are distinct from those mandated by local government (Johnson & Jani, 2016).

4.4. Smart cities

Connecting with big data is the movement to harness large datasets to improve the operations and management of government and services within neighborhoods and cities through advanced technologies. A 'smart city' is defined as "a synthesis of hard infrastructure (or physical capital) with the availability and quality of knowledge communication and social infrastructure. The latter form of capital is decisive for urban competitiveness" (Batty et al., 2012, p. 486, citing Caragliu, Del Bo, & Nijkamp, 2009). Most smart city applications, such as the real-time analysis of mass transit data for better prediction of ridership and congestion (see e.g. Batty, 2013), appear to be conventional applications of centralized, expert-driven analyses. However, Batty et al. (2012) acknowledge the potential for democratic participation via 'citizen science' regarding the nature, content and use of large datasets for urban operations and management (see Gregory & Atkins, 2018, for some reflections on the potential for connecting Community OR with citizen science).

Since smart cities have the potential to affect the lives of their residents at all times and in all places, there appear to be significant opportunities for Community OR to enable diverse stakeholders to influence the ways in which smart cities are designed and implemented, and to apply stakeholder engagement to define the real-life problems they purport to solve. In particular, Community OR can challenge common notions of technology as a mostly unalloyed good, emphasizing the role that smart city-focused technologies can play in expanding the reach of the surveillance state and highlighting class and social disparities in access to and use of smart city technologies and data (see, e.g. White & Trump, 2016).

IBM is a company that has invested significantly in the area of smart cities (e.g. Dirks & Keeling, 2009), and one of the authors (Gerald Midgley) was engaged with them for several years on the sticking points for implementation, which often concern the gover-

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nance of initiatives and not the technology. Here, the emphasis of Community OR on community and stakeholder engagement could make a significant difference to both the design of these initiatives to meet community concerns, and their eventual implementation. Since much of the literature on both Community OR and smart cities has been influenced by systems thinking, there is already enough of a common language to make a start.

4.5. Resilient cities

The notion of resilient cities addresses a myriad of contemporary challenges (such as economic development, social polarization and segregation, as well as climate change and ecological degradation) through the notion of planning, adaptation and response to immediate and long-term threats to human and community health (Spaans & Waterhout, 2017). Resilient cities are well-positioned to direct intervention in physical and social infrastructure in urbanized areas to redress inequalities and structural flaws. The importance of resilient cities is represented by the worldwide '100 Resilient Cities Program' sponsored by the Rockefeller Foundation. Research programs in resilient cities abound, including Boston in the USA (Martin, 2015); Rotterdam in the Netherlands (Spaans & Waterhout, 2017); Dhaka in Bangladesh (Walters, 2015); and Brisbane in Australia (Walters, 2015). These studies take as given the importance of community engagement and participation in risk assessment and planning for, and adaptation to, long-term changes in climate and the economy that could reduce quality of life, as well as displace and put at risk the lives of millions of people. They directly engage the notions of stress and trauma, not just as the result of discrete disasters, but as indicators of reduced well-being in response to chronic mal-adaptations of urban areas to global change, experienced locally. There appears to be a significant opportunity for Community OR to articulate community values, structure objectives and develop interventions in close cooperation with affected communities, especially those at greatest risk of harm due to low income, lack of political influence, low levels of social engagement, etc. See Helfgott (2018) for a project taking a significant step forward in this direction.

4.6. Developing countries

Countries in the 'global South' face a much different set of political, social and economic challenges than the developed countries in which OR was started (Rosenhead, 1993). From the increased severity of climate-change-related extreme weather events, to high levels of internal and external human displacement due to war, political instability and food insecurity, to daily life challenges arising from poverty, disease and a lack of good governance, developing country issues might initially seem to be too large and systemic to be addressed in a substantive way by Community OR, as opposed to well-established disciplines such as international development, human security and global governance. However, there has been consistent progress towards the creation of OR infrastructures in education and research in developing countries, as exemplified by Caulkins, Eeelman, Ratnatunga, and Schaarsmith (2008) and Maposa, Cochran, and Lesaoana (2016). Caulkins et al provide specific examples of OR teaching that can be easily adapted to resource-constrained environments, and which are responsive to decision problems arising from the African experience. Maposa et al. (2016) present a more traditional quantitative modeling-based approach to extreme weather event forecasting and response.

The literature on Community OR engagements in developing countries includes work by Ochoa-Arias (1994, 2004) in Venezuela; White (1994) in Belize; Sova, Helfgott, Chaudhury, Matthews, Thornton, and Vermeulen (2015) and Helfgott (2018) in Nepal; Tirivanhu, Matondi, and Sun (2016) in Zimbabwe; Espinosa and Duque (2018) and Pinzón-Salcedo and Torres-Cuello (2018) in Colombia; Mwiti and Goulding (2018) in Kenya; Romm (2018) in South Africa; Gomes, Hermans, and Thissen (2018) in Bangladesh; Burns (2018) in Myanmar; and Ufua et al. (2018) in Nigeria. There is also a more general review of OR applications in development (White, Smith, & Currie, 2011); a set of ideas for adapting Community OR to the needs of developing countries (Rosenhead, 1993); and a proposal for a new conception of public health in development based on Community OR principles and practice (Thunhurst, 2013). These works emphasize the roles that community engagement, qualitative methods, problem structuring and values-explicit inquiry may play in developing country settings.

4.7. Diversity and inclusion

Diversity can be broadly understood as encompassing individual characteristics that are often viewed or treated as markers of social difference or collective identity, as well as internal individual characteristics that may reflect personal understandings of the world. The latter are often referred to as cognitive diversity. Diversity always exists in social systems. Inclusion, on the other hand, often needs to be consciously enabled. In order to leverage diversity, an environment must be created where people feel safe, supported, listened to, valued and able to do their personal best. This is often a 'wicked problem' (to borrow a concept from Rittel & Webber, 1973), in the sense that inclusion initiatives tend to have numerous stakeholders, may interact with a variety of problems and attempted solutions, and trade-offs between values are difficult to state (or when stated, may be difficult for some stakeholders to accept).

There are many diversity and inclusion problems amenable to solution using traditional OR, such as public school assignment (Shi, 2015); college admissions (Chen & Kesten, 2016); and job interview process design (Johnson, Hekman, & Chan, 2016). However, the most challenging problems, particularly those requiring more comprehensive attempts to solve failures of inclusion, may not be accommodated by traditional approaches, and here we refer to things like gender diversity quotas, job guarantee programs and universal basic income design, for instance. It is difficult to imagine any of these being tackled competently without meaningful community engagement and without a critical awareness of the strengths and weaknesses of different approaches.

Examples of applications of Community OR to diversity and inclusion are presented by Pindar (1994), who focuses on racial harassment; Cohen and Midgley (1994) and Midgley and Milne (1995), who look at the marginalization and inclusion of people with mental health problems; Gregory, Romm, and Walsh (1994) and Gregory and Romm (2001), who discuss the empowerment of blind and partially sighted health service users; and Boyd, Brown, and Midgley (2004), who explain the design of a Community OR process that put the perspectives of homeless children at the heart of the development of services to meet their needs. This is an area that has already been of significant concern in Community OR; for a wider set of readings, see various chapters in Johnson (2012a), Midgley and Ochoa-Arias (2004b) and Ritchie et al. (1994). However, there is still the potential for further innovation, especially to build a practice-relevant theory of inclusion as a generic issue.

COR has the potential to build interventions around *critical* perspectives on diversity and inclusion. These interventions can account for many issues, such as power relationships that characterize the institution or phenomenon of interest; conflicts between stakeholders with different perspectives; the choice of preserving or replacing the current organizational structure in the interests of social justice; how community engagement should be defined;

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and the existence of roles for systems thinking and problem structuring methods in developing novel solutions to issues of diversity and inclusion (Johnson, 2016). The recent unveiling of a comprehensive and radical policy platform for the US-based Black Lives Matter movement (The Movement for Black Lives, 2016) provides a promising opportunity for Community OR practitioners to engage with local activists to develop interventions that support efforts for social change. One aspect of Community OR that could be particularly useful in this area is the theory of boundaries and marginalization processes that has informed a number of interventions (e.g. Barros-Castro et al., 2015; Boyd et al., 2004, 2007; Córdoba and Midgley, 2003, 2006, 2008; Foote et al, 2007; Midgley et al., 1998, 2007; Midgley, 2000, 2006, 2015; Midgley & Shen, 2007; Midgley & Pinzón, 2013; Shen & Midgley, 2015; Ufua et al., 2018).

4.8. Environmental issues

Traditionally concerned with stewardship and sustainability, environmental policy and action has broadened its focus to address systemic issues related to climate change, urban resilience and human adaptation. Central to all of these application areas is the role of community and stakeholder participation in both agenda setting and individual/collective action. Ulrich (1993) discusses the need for systems thinkers to engage the ecological movement without false pretensions that systems/OR can provide comprehensive analyses; rather, we should be aware of our boundary judgments and the values that inform them. Also see Midgley (1994) for a discussion of the frequent marginalization of environmental issues due to overly narrow boundaries defining economic and social concerns. Midgley and Reynolds (2001, 2004a,b) present an agenda for change in OR to meet the needs of environmental management, which includes a greater focus on stakeholder and community engagement. Waltner-Toews, Kay, Murray, and Neudoerffer (2004) offer a new Community OR methodology to integrate community engagement with scientific analysis in projects where both environmental and social values need to be accounted for in development proposals.

More recent OR on environmental issues includes the work of Schafer and Gallemore (2016) on the use of multi-criteria decision analysis for agenda setting in natural resources project funding; Pimentel, Santibañez Gonzalez, and Barbosa (2016) addressing modeling principles for decision support system development, focusing on environmentally friendly mining; and adaptations of principles of problem structuring methods and value-focused thinking for Life Cycle Sustainability Assessment in waste management systems (Souza, Rosenhead, Salhofer, Valle, & Lins, 2014). In this body of research, however, the role of community members, as opposed to planners and managers, does not appear to be prominent, so there is an opportunity here for Community OR practitioners to highlight the benefits of community-based intervention design, implementation and evaluation.

4.9. Indigenous people's issues

While much of the literature on Community OR originates from the UK and US, as the movement spreads into other countries with different cultural histories, Community OR theory and practice will come into contact with indigenous people. Indeed, there is already a small but growing literature on OR practitioners working with indigenous communities (Ahuriri-Driscoll, Baker, & Midgley, 2005; Ahuriri-Driscoll & Foote, 2016; Brocklesby & Beall, 2018; Espinosa & Duque, 2018; Foote et al., 2005; Foote, Hepi, Rogers-Koroheke, & Taimona, 2017; Hepi, Foote, Rogers-Koroheke, & Taimona, 2007; Jellie et al., 2003; Midgley et al., 2007; Morgan and Fa'aui, 2018). The term 'indigenous' refers to the 'first people' in any given country, who were there before colonizing forces arrived (Smith, 1999). There are various people around the world who are trying to preserve their native cultures despite sometimes overwhelming pressure to give up their ancestral lands, languages and identities – and there are others (such as Māori in New Zealand) who have survived this cultural imperialism and are now resurgent, despite continuing inequality and disadvantage. They are developing their languages and identities in new directions while still firmly anchored in their cultural history and traditions.

Working with indigenous people raises issues that are not encountered in any other setting. For a start, Western science, including the language and methodologies of OR, can be viewed as an instrument of domination because, historically, indigenous people have been subject to the 'objective' gaze of researchers who viewed their cultures as alien curiosities or ridden with primitive superstitions (Smith, 1999). This attitude has left deep suspicions amongst indigenous communities that scientists and operational researchers are at best going to take from them (in the form of publications and reputation) without giving anything in return, and at worst are going to assume that they have a superior rationality that validates the imposition of their own problem definitions and solutions without proper community engagement. These suspicions are amplified when the OR practitioners are employed by institutions that were originally founded by colonists (such as government departments), and non-indigenous Community OR practitioners therefore have to be strongly aware of identity issues and build relationships with communities over time and with cultural sensitivity (Midgley et al., 2007; Walsh, Kittler, & Mahal, 2018). Indeed, in recent years, there have been movements in some indigenous communities to create their own methodologies, grounded in their own cultures. A good example is *Kaupapa Māori* in New Zealand (Bishop, 1996; Smith, 1999), which involves research by Māori, for Māori. Non-Māori OR practitioners can be involved, as long as the leadership sits with Māori themselves. This poses a significant challenge to OR practitioners, who need to negotiate everything, including whether they will be allowed to publish under the banner of Community OR!

There can also be cultural conflicts: while many indigenous methodologies are highly participative, there may be elements of local village culture that limit participation in ways that make non-indigenous researchers feel deeply uncomfortable. A good example in New Zealand is that a minority of Māori villages hold communal meetings where only men participate in the 'inner circle' and women have to sit silently around the edge – their marginalization physically expressed in the seating arrangements. There are arguments in New Zealand about whether this tradition is an original Māori one or whether it was imposed by Christian missionaries, but whichever is the case, encountering this situation can place equality-minded Community OR practitioners in an ethical dilemma: whether to accept the local culture or speak out in favor of gender equality (Ahuriri-Driscoll, 2005).

Despite these issues – *and indeed because of them* – the learning opportunities for Community OR practitioners are substantial. First of all, when working in communities where there is a strong culture of indigenous research, lessons can be learned about the full potential of community leadership in co-creating OR projects (also see Ackoff, 1970, who worked in a non-indigenous context, but one where the project was constructed to give local people full leadership responsibilities). The potential is there for much more exciting and community-relevant outcomes, and for alternative theories, methodologies and practices of Community OR that are culture-specific. Also see various discussions of culture-specific Systems/OR methodologies in non-indigenous, non-Western contexts (e.g. Gu & Zhu, 2000; Li & Zhu, 2014; Midgley and Wilby, 1995, 2000; Midgley, Gu, & Campbell, 2000; Midgley & Shen, 2007; Murthy, 1994; Shen & Midgley, 2007a, 2007b, 2015; Tan, Watson, & Wei, 1995; Wang, 2000; Zhu, 2000).

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Table 1
Summary of emerging trends and new frontiers in Community OR.

Emerging Trends	
Disaster planning	Community OR may enable an integration of various stakeholders' experiences and preferences, especially neighborhood-level community preparation, directly into an enhanced model of disaster planning and response.
Analytics	Community OR emphasizes questions of what data can and should do for individuals and communities, and how community residents themselves can work to define, collect and analyze data that are relevant to their own lives.
Behavioral operational research	Community OR can be enhanced by Behavioral OR analyses that demonstrate what works best in participative modeling processes, and how meaningful engagement can be enhanced.
New Frontiers	
Urban planning and community development	Many urban planning applications are still entirely quantitative, modeling-driven approaches; Community OR can identify local values associated with community revitalization and develop relevant metrics.
Information systems and information technology	Community OR can contribute to the IS/IT literature on citizen engagement by emphasizing community-engaged methods for ICT planning, design and implementation.
Big and difficult data	Community OR has a unique perspective on local agency, and uses a critical approach to identify applications for data collection, analysis and use for local development. Community OR methods may be useful when there is a lack of consensus on sources, variables and uses for data.
Smart cities	Community OR may challenge notions of technology as a mostly unalloyed good, emphasize the role that smart city-focused technologies can play in expanding the reach of the surveillance state and highlight class and social disparities. It may also provide useful methods for citizen and stakeholder engagement to improve the governance of smart city initiatives and make them more responsive to grass-roots community concerns.
Resilient cities	Community OR may help structure objectives and develop interventions in close cooperation with affected communities, especially those experiencing stress and trauma.
Developing countries	Community OR methods could be especially adapted to resource-constrained environments and to decision problems arising from the experiences of people in developing countries.
Diversity and inclusion	Issues of inclusion are often "wicked" problems requiring the involvement of numerous stakeholders who need to get to grips with multiple interactions with other problems as well as clarify and discuss conflicting and poorly-articulated values. Community OR can help define crucial notions of community engagement, and bring in useful systems theories of boundaries and marginalization processes.
Environmental issues	Community OR may highlight the special nature of community-based intervention design, implementation and evaluation; Community OR methodologies should be able to integrate community engagement with scientific analysis.
Indigenous people's issues	Community OR is concerned with meaningful engagement, co-creating interventions with community-based partners and using methodologies and methods for empowerment. All of these are essential to working with integrity in indigenous communities. In addition, Community OR researchers may experience indigenous methodologies and methods and examine (with the permission of their curators) whether they are transferable or adaptable to other cultures elsewhere in the world.

The other significant opportunity for learning is to experience indigenous methodologies and methods and see whether they are transferable or adaptable to other cultures elsewhere in the world–with the permission of their indigenous curators, of course, and giving credit to the original contexts in which these approaches were developed. This could substantially enrich our Community OR toolkits, and is ethical as long as the sharing is voluntary and two-way; i.e. it is a case of indigenous communities enriching their own practice on their own terms as well as non-indigenous communities learning from them.

5. Conclusion

We have identified areas in which Community OR can enrich, and be enriched by, current research in multiple domains within and outside the decision sciences: disaster planning (including humanitarian logistics); analytics; behavioral OR; urban planning and community development; information systems and information technology; big and difficult data; smart cities; resilient cities; developing countries; diversity and inclusion; environmental issues; and indigenous people's issues. Across these domains, within and beyond OR, we have argued that all of the following aspects of Community OR can enrich our understanding of theory, methods and outcomes: its notions of intervention, local engagement and impact; its frequent concern for disadvantaged, underrepresented and underserved populations; its emphasis on problem solving processes as well as outcomes; its critical attitude and concern for ethics; its leaning toward qualitative and mixed method approaches; and, in general, its concern for community empowerment and social change. We have summarized these findings in Table 1.

It seems to us that wider engagement (beyond clients) and a critical perspective are particularly important when developing new approaches to analytical thinking for creative problem solving across disciplines and applications. While these notions are well accepted in some social science and transdisciplinary research communities, they are less commonly understood in the decision sciences – but this is where they arguably matter most, because the decision sciences are so concerned with application and impact. Thus, like Jackson (1987, 1988) and Midgley et al. (2018), we claim that a greater appreciation for the potential of Community OR principles, theory, methodology and methods – especially in relation to engagement and critical thinking – can enrich the decision sciences.

The analysis in this paper leads us to propose some potential implications for the theory, methods and practices within the decision sciences. First, the conception of 'community' can be broadened to address online as well as in-person communities (also see Yearworth and White, 2018); ones that are geographically concen-

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trated as well as spatially dispersed; those that are defined by immutable versus changeable characteristics; and those that cohere around visible versus invisible characteristics. This issue is especially salient to urban planning and community development, information systems and information technology, diversity/inclusion and environmental issues. In these domains, questions of which stakeholder groups 'count', how they are affected by decision problems, and how their views can be incorporated into interventions are important and challenging.

Second, the notion of 'problem solving' can be broadened to encompass novel understandings of individual and collective values, motivations for action, cultural perceptions in organizations and systems, as well as more traditional notions of policies, prescriptions and new procedures. This notion is important in humanitarian logistics, for example, where questions about how problems should be solved, and what the impacts of a problem solution might be on affected groups (beyond technical and logistical concerns), could receive more attention than they do at present, especially in the US OR context. This notion is important in a different way for indigenous people's issues, where cultural conflict, and the contrast between the perspectives of the researcher and the researched, make traditional applications of OR problematic.

Last, the notion of a disciplinary 'home' or frame for inquiry can be loosened somewhat (especially in the US context) so that, for example, urban planning, analytics or information systems can become more accepting of Community OR thinking.

Regarding methods, we have argued that Community OR practitioners generally show a greater willingness than many others in the decision sciences to use mixed method designs to solve challenging problems; to connect interventions with systemic analyses wherever possible, rather than deal with superficial symptoms of deeper social problems; and to identify high-impact human outcomes, as compared with technical system change. We see these concerns as especially important for diversity and inclusion, environmental issues and working in developing countries; in these areas, multiple analytical methods are commonly applied within specific disciplinary domains, but less often imported across disciplinary boundaries. To take just one example, how could a traditional approach to diversity and inclusion in an organization, as enhanced through decision science principles, deal with the concerns of members of underrepresented or marginalized groups who may not actually participate within that organization at present? We suggest that any credible project addressing this question would have to engage communities in the manner that is common in Community OR projects.

Regarding practice, we are reminded of the importance of interrogating common, disempowering assumptions about the roles that communities and their representatives should play in relation to problem solving in the agencies that serve those communities. More openness and flexibility is needed, especially when identifying problems, to make sure that agencies are not missing crucial issues. Within projects, insights, modeling and suggestions for change need to be better connected to stakeholder values, to improve local relevance. Again, especially in the US context, we suggest that technological–managerial solutions are essential but not sufficient. These insights seem especially important to the analytics, smart cities and big data movements, which often appear more interested in technologies, markets and data than in ways that they can engage underrepresented communities and define outcomes in terms that are relevant to diverse groups of citizens.

These implications for theory, methods and practice may provide the basis for a research agenda that *engages Community OR with the decision sciences more generally*. Such an agenda should embrace concerns with inter- and trans-disciplinary inquiry, systems thinking, community engagement, equity and social justice, and the implementation of solutions that embrace changes to human as well as technological systems. The current fraught political environments in the US and the UK increase the importance of such values, and suggest that researchers outside the US and UK have a special opportunity to develop extensions to Community OR and the decision sciences to support local development and community empowerment based on empiricism and critical inquiry for improved problem solving.

Acknowledgment

Gerald Midgley's participation in writing this paper was part-funded by the UK Natural Environment Research Council (NERC) and the Economic and Social Research Council (ESRC) through project NE/L014211/1 under the Resource Recovery from Waste theme.

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Please cite this article as: M.P. Johnson et al., Emerging trends and new frontiers in community operational research, European Journal of Operational Research (2018), https://doi.org/10.1016/j.ejor.2017.11.032

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Please cite this article as: M.P. Johnson et al., Emerging trends and new frontiers in community operational research, European Journal of Operational Research (2018), https://doi.org/10.1016/j.ejor.2017.11.032